International Journal of Science and Engineering Applications
Volume 12-Issue 09, 59 – 61, 2023, ISSN:- 2319 - 7560
DOI: 10.7753/IJSEA1209.1020

Application of Doppler Radar Data in Rainstorm Forecast

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Abstract: The influence of time step, grid size, rain intensity threshold and other parameter changes in TREC method on tracking results is discussed, and the TREC vector field is smoothed, which to a certain extent reduces some obviously wrong vectors caused by ground object echoes and echo gradient changes in the TREC vector field, obtains a more continuous vector field, and uses the vector field obtained to predict the approaching rainstorm. The radar echo characteristics of mesoscale systems in the rainstorm process, such as low-level jet, warm advection, warm shear, cold shear, and headwind area, are analyzed; Through their identification and comparison with precipitation characteristics and rainstorm falling areas, it is shown that these mesoscale systems have clear indication significance in the near forecast of rainstorm.

Keywords: Doppler Radar, rainstorm Forecast

1. INTRODUCTION

Doppler weather radar data has high temporal and spatial resolution and plays an important role in mesoscale catastrophic weather research and near prediction. In the mature time zone of the headwind zone, the color gradually transitions from light to deep, and the wind speed gradually transitions from small to large according to the color hierarchy, which is fundamentally different from velocity ambiguity. Speed blurring is usually a sudden change in warm and cold tones, with the negative (positive) speed maximum zone appearing in the positive (negative) speed maximum zone, while the upwind zone is another type of speed zone appearing in the speed zone. A standard that can be used for radar detection and analysis is a low-level strong wind speed zone with a horizontal distance of ≥ 80km, an altitude below 3000m, a time scale of ≥ 2 hours, a horizontal wind speed of ≥ 10m · s-1, and consistent wind directions.

The time scale here serves as an additional condition primarily to distinguish low-level jet streams from instantaneous strong winds after warm shear. In addition, the low-level jet can cross a height of 3000m and connect with the hollow jet. The Shanghai Meteorological Bureau has also established a short-term forecast system for severe convective weather in the Shanghai area based on the mesoscale numerical prediction model prediction products and a human-machine interaction platform. The system integrates satellite, radar, automatic stations, and high-altitude ground observation data, and combines the experience of forecasters. The extrapolation method for the movement of radar echoes assumes that the movement of radar echoes is guided by environmental wind fields, and there is no significant sudden change in the environmental wind field within 60 minutes.

Therefore, by determining the environmental guidance wind field, an effective difference format can be used to extrapolate and predict radar echoes. The above two methods are used to obtain the movement vector of the radar echo at the current time, and the two vectors are assumed to be the guiding wind vector of the radar echo movement respectively, to realize the extrapolation prediction of the radar echo in Lagrange coordinates. There is an ENE-WSW weak echo zone located approximately 15km south of Baise, with a small range and weak intensity of individual echoes within the zone. The height is generally 6-7km, but the highest is only 9km. The connection between the individual echoes is not tight, and the echo zone moves southward at a speed of approximately 16-17km per hour.

Compared with the Radial velocity map at that time, we can see that there is an "L" shaped zero velocity line. This obvious feature, combined with the echo belt trend, can determine that the echo belt is a frontal cloud belt. The frontal echo zone moves southward into the convergence flow field and develops. The strength and width of convection cell in the zone increase, and the moving direction gradually tends to be parallel to the trend of the zone, which makes the echo zone width increase significantly, and the southward moving speed gradually slows down to about 10km per hour, which is very conducive to the occurrence of heavy rainfall. Short term heavy rainstorm occurs in the front of the upwind zone and the region with the largest Radial velocity convergence. The so-called upwind zone means that there is a positive velocity zone in the negative velocity zone of Radial velocity or a negative velocity zone in the positive velocity zone, and there is a zero-velocity transition zone between the two.

Who includes who among them is influenced by factors such as local environmental wind and antenna elevation. Due to the lack of corresponding ground level wind observation data, it is still difficult to determine the properties of its mesoscale system. Since the forecast object is rainstorm, four PPI data with lower elevation angle are selected, and the data at the selected altitude are obtained by Linear interpolation using the height measurement formula. For radar range.

2. THE PROPOSED METHODOLOGY

2.1 The working method of Doppler radar

There are two echo bands in the northern part of Baise. The echo band in the north descends from the northeast of Guizhou to Yunnan, while the echo band in the south is a discontinuous band formed during the northward uplift of convective echo cells. The two echo bands move in opposite directions and converge in the northwest of Tianlin. At 22:00, the two echo bands merge into one, forming an E-W wide mixed layered strip echo. The echo band has a bandwidth of about 80km, a band length of more than 350km, and the echo intensity is mostly less than 40dBZ. The echo height is

generally 8-10km. On the profile map, the echoes are arranged tightly, in clusters, and the top of the echo is a multi-peak structure. In the southern part of the station, there is continuous convective generation and development, merging to form a large area of echoes and merging into the echo zone during northward movement, resulting in the development of the echo zone and the expansion of the precipitation area.

Near the center of the low-level jet (slightly to the left), it also indicates the center of the rainstorm. In addition, the time when the two SE low-level jets end, i.e., when the low-level jet reaches its peak and transforms into weaker airflow, is the time when the two periods of heavy precipitation begin; This largely reflects the relationship between the oscillation of low-level jet streams and heavy precipitation. To eliminate some incorrect movement directions and improve the continuity of the TREC vector field, the following two steps were taken for continuity check: if the average direction of a TREC vector differs by more than 20 from its surrounding vector, the average vector of 8 points around it is used to replace the TREC vector, and the zero vector also adopts this method.

Objectively analyze the TREC vector to obtain a continuous displacement vector field. The scoring results of Scheme 2 indicate that when the forecast duration is 30 minutes, the ICS at a height of 2.0 km among the eight altitudes is the highest, accounting for 78.64%, followed by 3.0 and 3.5 km. When the forecast duration is 60 minutes, the three best predicted heights are 2.0, 2.5, and 3.0 km, respectively.

From this, the prediction effect of Scheme 2 at altitudes of 2.0-3.5km is better than other altitudes. The combined effect of multiple mesoscale systems is a key factor contributing to this large-scale heavy rainfall. The two echo belts merged and developed and maintained for a long time, resulting in rainstorm in the north of Baise and heavy rainstorm in some areas. The heavy rainstorm is distributed near the convergence area of the two echo belts, namely the southeast of Longlin, the west and north of Tianlin, Lingyun, the south of Leye and the northwest of Baise. Among them, 7 of the 10 towns in Lingyun County located in the strong echo area of the echo belt suffered heavy rainstorm, and the 24-hour rainfall in Lingyun County seat was 193.8mm.

In addition, due to the continuous generation, development, and merger of convection in the southern region, a large area of echo has moved northward, and moderate to heavy rain and local rainstorm weather have also occurred. Warm shear has a prediction time limit of 0-3 hours for heavy precipitation; After one hour of high-level cold shear, the heavy precipitation stopped and later turned into weak precipitation within the air mass. In the extrapolation forecast of typhoon rainstorm, the semi Lagrangian one-dimensional advection formula is respectively applied to the u and v components of the TREC vector, and the time step is 6 minutes. The displacement on the u and v components is calculated respectively, and the forecast results are output once every 6 minutes. The rain intensity value, direction, and speed on each grid point currently are used as the integral of the next continuous time.

2.2 Sensitivity test and tracking results of parameters

The VAD method inverts the horizontal wind of each layer as a moving vector for echo extrapolation. Within a prediction duration of 60 minutes, the overall movement trend of the radar echo can be predicted, and the predicted echo range and position are in good agreement with the actual situation, making it suitable for monitoring the movement and evolution of convective weather systems near the observation station. A prominent feature of the VPPI Radial velocity field is the continuous warm advection in the lower layer. From 00:35 to 11:09 on the 12th, the VPPI Radial velocity field can be easily identified. The zero-velocity line has an s-shaped structure, and through the station, the wind direction from low to high turns from SE to S to SW, that is, the wind direction turns clockwise with height. This feature is like the simulated Doppler velocity image of wind turning clockwise with height in a uniform wind field, indicating the existence of warm advection.

By comparing predicted images with radar measured images, a qualitative description of the predicted results can be obtained, and quantitative analysis of the predicted results can also be conducted. Compare the predicted data with the actual radar observation data at the prediction time one by one. If both the measured and predicted grid data are greater than the threshold, the grid point is considered successful. If the measured grid data is greater than the threshold but the predicted grid data is less than the threshold, the grid point is considered a false alarm. If the measured grid data is less than the threshold but the predicted grid data is greater than the threshold, the grid point is considered a false alarm. The radar echo positions obtained within the next 60 minutes are basically consistent with the actual radar situation at the corresponding time, and the prediction scores of the two are relatively close at certain altitudes, and the altitude layer with the best prediction effect corresponds well; From two extrapolation experiments, it was found that the key to the effectiveness of extrapolation is related to the vertical distribution of horizontal winds in precipitation echoes, and cannot be limited to only 2.5-3.0 km.

Cloud microphysical products provide 24-hour forecast fields for 10 microphysical quantities at altitudes such as 600hPa, 550hPa, 500hPa, and 400hPa. These products to some extent fill the gap in cloud microphysical detection in current conventional meteorological observation projects and provide important cloud microphysical reference basis for weather modification operations in our region. The size of the rectangular grid on radar images is constrained by two factors. If the grid is too small, stable correlation coefficients cannot be obtained due to the lack of data. If the rectangular grid is too large, it provides an average moving vector, which can easily smooth out some small-scale changes.

Taking Typhoon Kanu in 2005 as an example, the influence of rectangular grids of different sizes on the TREC vector field was analyzed. The selected rectangular grid sizes were 15km~15km, 20km~20km, and 30km~30km. From the TREC vector field, it can reflect the circulation characteristics of typhoons. However, the rectangular grid with a 15km vector field has more chaotic directions in the circulation, and the circulation of the other two vector fields is smoother. From the rectangular grid with a 20km vector field, the merging characteristics of the strong echo area can be seen, while the rectangular grid with a 30km vector field smoothest out this feature.

3. CONCLUSION

To study the Kinematics and dynamic characteristics of Convection cell movement, Doppler radar reflectivity factor and Radial velocity data are comprehensively used to study the echo proximity prediction algorithm. The vertical profile of wind retrieved by technology is an important supplementary tool for studying mesoscale systems, which

can more intuitively display the local evolution characteristics of the mesoscale systems. The large-scale rainstorm is more represented by the comprehensive effect of the above mesoscale system; All mesoscale systems in the rainstorm area have a clear indication role in the approaching forecast of rainstorm.

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